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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A description of the software to analyze lung function using a spirometer-magnetometer system is presented. The software plots, compares, and processes the data and fits a variety of mathematical models to the data. The software package is designed for interactive use. A user guide is included.

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MEASUREMENT OF LUNG FUNCTION USING MAGNETOMETERS.

II. Data Acquisition and Analysis.

Donald L. Vawter, Ph.D.

The Hyperbaric Medicine and Physiology researchers who measure lung
function using magnetometers currently use the program DATLOG to sample and
store the magnetometer and spirometer output. To better visualize the
chest and abdomen during the motion of respiration, we have developed a
software package for plotting the sample data and for fitting a variety
of models to the data. There are five basic programs discussed briefly in
this report. The programs are interactive in nature and largely self-
explanatory. The use of the programs on one particular data set is
presented in Appendix 1, which should serve as a user's guide.

PROGRAM ALLDAT

This program prints the data stored on the specified input file.
The input file should be in the form generated by DATLOG. The user
has the option of printing out data at only a few points. This program
is generally only useful for inspecting data for spurious points. The
FORTRAN listing is contained in Appendix 2.

PROGRAM PLT

Program PLT has three functions:

1)   Prepare a data file for plotting the data automatically,
      using program [1,100] PLOT. The spirometer output and the
      output from each magnetometer will be plotted. The user must
      input the name for the plotfile to be generated.

2)   "DC Offset" the data. It may be useful in some situations
      to force the data set to be zero at either the start or the
      end of the data set. For example, because the change rather than
      absolute volume is important, one may wish to subtract the
      spirometer reading at the first data point from all values
      in the data set. This is especially useful if the first data
      point corresponds to end-expiratory values. The use of
      software to accomplish this function has an advantage over
      the previous method of offsetting the data electronically by
      use of a low-pass filter system. The advantage is that the
      "raw" data is not altered. Hence, if one discovers later
      that the initial point does not correspond to end expiration,
      one still has the original data set. The offset feature is
      also useful if there is drift present in the data. One can
      then offset the data by the average of the first and last
      data values. This, of course, works only if both points
      correspond to the same point in the respiratory cycle.

1

3) Search the data and determine the minimum and maximum values of the data for each channel. Thus, one can tell at a glance the excursions of the chest and abdomen and also the volume excursion for that data set. The FORTRAN listing of PLT is in Appendix 3.

PROGRAM COMPARE

Program COMPARE prepares a data set for plotting one channel data versus any other channel. For example, one can plot the change in anterior-posterior (A-P) chest diameter versus volume, or one can compare the change in A-P chest diameter versus the change in lateral chest diameter. The data set generated is compatible with the automatic plotting program [1,100] PLOT. The FORTRAN listing for COMPARE is found in Appendix 4.

PROGRAMS M1 to M7

These programs determine the constants for the seven models discussed below. The FORTRAN listing for Model 7 is found in Appendix 5. For the other models, the array "S" is altered according to the definitions in reference 1.

PROGRAM CALC

Program CALC generates data files for plotting the model curves on the VERSATEC plotter. The program also determines whether adding a constant to the predicted volume lowers the error. The program asks the user whether he wishes to use the offset. The offset should be used only when predictive results are desired and not for calibration curves. The FORTRAN listing is in Appendix 6.

The equations for Models 1 through 7 are given below.

Model 1: $V = K_1*(DC - DCO) - K_2*(DA - DAO)$

Model 2: $V = K_1*(APC - APCO) - K_2*(APA - APAO)$

Model 3: $V = K_1 - K_2*(APA - APAO)$

Model 4: $V = K_1*(APC - APCO) - K_2$

Model 5: $V = K_1*DC - K_2*(DC/DA) - K_3$

Model 6: $V = K_1*(DC - DCO) - K_2*(DC/DA - DCO/DAO) - K_3$

Model 7: $V = K_1*DC - K_2*DA - K_3$,

where V is volume, DC is the cross-sectional area of the chest, DA is the cross-sectional area of the abdomen, APC is the A-P diameter of the chest, and APA is the A-P diameter of the abdomen. The corresponding values at FRC (measured with callipers) are followed by "0". K_1, K_2, and K_3 are unknown constants that are determined by minimizing the squared error.

In the previous equations, although they are not anatomical models, we still assume the cross-sections of the abdomen and chest are elliptical when calculating areas.

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2.   Konno, K., and J. Mead. Measurement of the separate volume changes
of rib cage and abdomen during breathing. J. Appl. Physiol. 22:407-422,
1967. AD AO 60473

3.   Robertson, C.H., M.E. Bradley, L.M. Fraser, and L.D. Homer. Computerized
measurement of ventilation with four chest wall magnetometers. Naval
Medical Research Institute, Bethesda, MD., 1978.

Appendix 1: Step By Step Guide to the Programs

```
************************************************************

     EXAMPLE OF USING PROGRAM ALLDAT TO INSPECT DATA


************************************************************

RUN ALLDAT
 FILE NAME?  DK:PSRB.DAT#1
 PRINT EVERY ?TH POINT?  10
 EVERY  10TH POINT IS PRINTED


        0.5824        0.2149        0.4782       -0.3183        0.7462
        1.1353        0.4739        0.7131       -0.0307        0.8708
        1.4856        0.5502        0.9084        0.2076        0.8653
        1.3799        0.5329        0.9054        0.1524        0.7831
        1.0560        0.3948        0.7513       -0.0481        0.6531
        0.5427        0.3056        0.4279       -0.2806        0.5079
        0.0448        0.0365        0.2478       -0.3968        0.4805
       -0.2305       -0.0843        0.2066       -0.5508        0.3313
        0.1748        0.0941        0.2997       -0.4259        0.5216
        0.8534        0.3948        0.6079       -0.1411        0.6106
        1.3953        0.5315        0.8810        0.1582        0.7243
        1.4856        0.5861        0.9191        0.2570        0.7968
        1.1353        0.4380        0.7864        0.0216        0.6763
        0.6352        0.3085        0.4858       -0.2748        0.5134
        0.1484        0.1027        0.2356       -0.3823        0.4395
       -0.1799       -0.0814        0.2021       -0.4956        0.3751
       -0.0235       -0.0095        0.2082       -0.4840        0.4381
TT2  --  STOP
>
```

```
*********************************************************************


EXAMPLE  USING PLT TO PREPARE DATA FOR PLOTTING


*********************************************************************


RUN PLT
 INPUT FILENAME   DK:PSRB.DAT;1
 WRITE MODIFIED DATA TO FILE?NO
 PTS   170   NO OF DATA POINTS FOR DC AVE 0,0
    0   0
 OFFSETS        0.000       0.000       0.000       0.000       0.000
 PREPARE DATA FOR PLOT?   YES
 FILE NAME FOR PLOT DATA?   TEST.PLO;1
 PLOT EVERY ?TH DATA POINT    2
       CHANNEL    J        MIN       J       MAX        DIFFERENCE
          1      155     -0.250     107     1.538        1.789
          2      156     -0.120     106     0.602        0.722
          3      159      0.190     104     0.927        0.737
          4      155     -0.562     108     0.266        0.828
          5      155      0.298      12     0.883        0.585
  ANY MORE   ?    YES
 INPUT FILENAME   DK:PSRB.DAT;1
 WRITE MODIFIED DATA TO FILE?YES
 OUTPUT FILE NAME   PSRB.MOD;1
 PTS   170   NO OF DATA POINTS FOR DC AVE 1,0
    1   0
 OFFSETS        0.582       0.215       0.478      -0.318       0.746
 TRUNCATE DATA?   NO
 PREPARE DATA FOR PLOT?   YES
 FILE NAME FOR PLOT DATA?   TEST.PLO;2
 PLOT EVERY ?TH DATA POINT    2
       CHANNEL    J        MIN       J       MAX        DIFFERENCE
          1      155     -0.833     107     0.956        1.789
          2      156     -0.335     106     0.387        0.722
          3      159     -0.288     104     0.449        0.737
          4      155     -0.244     108     0.584        0.828
          5      155     -0.448      12     0.137        0.585
  ANY MORE   ?    NO
TT2  --  STOP
>
```

```
***********************************************************************


PREPARING THE PLOTS FROM DATA SET GENERATED IN PLT


***********************************************************************


@[1,100]PLOT
>RUN [110,110]PLOT.TSK

        PROGRAM PLOT      09:05:13        08-AUG-79
DATA FILE? [DEV.NAME.EXT;VER]   TEST.PLO;1
NUMBER OF GRAPHS ON THIS SHEET? (MAX 10) 5
X MINIMUM AND X MAXIMUM?
Y MINIMUM AND Y MAXIMUM?   -1.,2.
X AXIS LABEL? <80 CHAR>
SAMPLE POINT(TIME)
Y AXIS LABEL? <80 CHAR>
OUTPUT(L,CM)
NO. OF DECIMAL DIGITS FOR LABELING AXES? 2
ANY NOTES? <YES OR NO> YES
NOTE? <80 CHAR> TEST.PLO;1
POSITION? (X,Y) .5,8.
ANY MORE? NO
--------___CALCULATING VECTORS___--------
WANT GRID PATTERN ON THE GRAPH? <YES OR NO> NO
09:08:11       08-AUG-79
ANY MORE PLOTS? YES
DATA FILE? [DEV.NAME.EXT;VER]   TEST.PLO;2
NUMBER OF GRAPHS ON THIS SHEET? (MAX 10) 5
X MINIMUM AND X MAXIMUM?
Y MINIMUM AND Y MAXIMUM?   -1.,2.
X AXIS LABEL? <80 CHAR>
SAMPLE POINT(TIME)
Y AXIS LABEL? <80 CHAR>
OUTPUT(L,CM)
NO. OF DECIMAL DIGITS FOR LABELING AXES? 2
ANY NOTES? <YES OR NO> YES
NOTE? <80 CHAR> TEST.PLO;2
POSITION? (X,Y) .5,8.
ANY MORE? YES
NOTE? <80 CHAR> A = VOLUME;  B = AP CHEST;  C = LAT CHEST
POSITION? (X,Y) .5,7.5
ANY MORE? YES
NOTE? <80 CHAR> D = AP ABDOMEN;  E = LAT ABDOMEN
POSITION? (X,Y) .5,7.
ANY MORE? NO
--------___CALCULATING VECTORS___--------
WANT GRID PATTERN ON THE GRAPH? <YES OR NO> NO
09:10:59       08-AUG-79
ANY MORE PLOTS? NO
TT2  --   STOP  END OF PROGRAM PLOT
>* WHAT IS YOUR TERMINAL NUMBER "TTN" [S]: TT2
>NFT @PLTT2
>PIP PLTT2.CMD;*,PLTT2A.CMD;*,PLTT2B.CMD;*/DE
>@ <EOF>                              -8-
>
```

```
************************************************************************


FITTING VARIOUS MODELS TO DATA SET


************************************************************************


RUN M1


  FILE NAME   DK:PSRB.DAT;1
  INITIAL VOLUME?   0
  APC,LATC,APAB,LATAB  =?   20.7,36.,20.7,30.5
  APC =  20.7  LC =  36.0  APAB =   20.7  LAB =   30.5
  -0.24825090E+09
  V = A*(AC-AC0) - B*(AA - AA0)

  A =  0.31541519E+02   B = -0.27743046E+02
  PRINT EVERY   ?TH PT?10


     POINT       MEASURED       CALC         ERR
      1           582.4         559.3        -23.1
     11          1135.3        1168.5         33.2
     21          1485.6        1501.1         15.4
     31          1379.9        1408.6         28.7
     41          1056.0        1006.6        -49.4
     51           542.7         534.7         -8.0
     61            44.8         108.8         64.0
     71          -230.5        -190.3         40.3
     81           174.8         185.7         10.9
     91           853.4         849.5         -3.8
    101          1395.3        1371.7        -23.6
    111          1485.6        1542.1         56.4
    121          1135.3        1122.1        -13.2
    131           635.2         573.8        -61.4
    141           148.4         153.5          5.2
    151          -179.9        -133.6         46.2
    161           -23.5         -30.4         -7.0

  ERROR SQ   0.2928E+06    ERRSQ/N   0.1723E+04   RMS   0.4150E+02
  CORRELATION COEFFICIENT    0.9978
  ANY MORE ?N
 TT2  --  STOP
 >
```

```
RUN M2


 FILE NAME   DK:PSRB.DAT;1
 INITIAL VOLUME?   O
 APC,LATC,APAB,LATAB  =?  20.7,36.,20.7,30.5
APC =   20.7  LC =   36.0  APAB =  20.7  LAB =   30.5
 -0.36518832E+03
 V = A*(D1C-D1CO) - B*(D1A - D1AO)

A =   0.24866968E+04    B = -0.14099380E+03
 PRINT EVERY   ?TH PT?10


    POINT      MEASURED      CALC        ERR
      1         582.4        489.6       -92.7
     11        1135.3       1174.2        38.8
     21        1485.6       1397.4       -88.2
     31        1379.9       1346.7       -33.2
     41        1056.0        974.9       -81.1
     51         542.7        720.4       177.6
     61          44.8         34.9        -9.9
     71        -230.5       -287.3       -56.8
     81         174.8        173.9        -0.9
     91         853.4        961.8       108.5
    101        1395.3       1343.9       -51.4
    111        1485.6       1493.8         8.2
    121        1135.3       1092.1       -43.2
    131         635.2        728.3        93.1
    141         148.4        201.6        53.2
    151        -179.9       -272.4       -92.5
    161         -23.5        -91.8       -68.4

 ERROR SQ   0.7859E+06   ERRSQ/N   0.4623E+04   RMS   0.6799E+02
 CORRELATION COEFFICIENT    0.9935
 ANY MORE ?NO
TT2  --  STOP
>
```

```
RUN M3


 FILE NAME   DK:PSRB.DAT;1
 INITIAL VOLUME?  0
 APC,LATC,APAB,LATAB  =?  20.7,36.,20.7,30.5
APC =  20.7  LC =  36.0  APAB =  20.7  LAB =  30.5
 -0.19503306E+04
 V = A*(1.) - B*(D1A - D1A0)

A =  0.10705438E+04   B = -0.22330249E+04
 PRINT EVERY  ?TH PT?10


    POINT      MEASURED      CALC        ERR
     1          582.4        359.7      -222.7
    11         1135.3       1002.1      -133.3
    21         1485.6       1534.2        48.6
    31         1379.9       1410.9        31.0
    41         1056.0        963.1       -92.9
    51          542.7        444.0       -98.7
    61           44.8        184.5       139.6
    71         -230.5       -159.4        71.1
    81          174.8        119.6       -55.2
    91          853.4        755.5       -97.8
   101         1395.3       1423.9        28.6
   111         1485.6       1644.5       158.9
   121         1135.3       1118.9       -16.5
   131          635.2        457.0      -178.2
   141          148.4        216.9        68.5
   151         -179.9        -36.2       143.7
   161          -23.5        -10.2        13.3

 ERROR SQ   0.2181E+07   ERRSQ/N   0.1283E+05   RMS    0.1133E+03
 CORRELATION COEFFICIENT     0.9815
 ANY MORE ?NO
TT2  --  STOP
>
```

RUN M4


```
FILE NAME   DK:PSRB.DAT#1
INITIAL VOLUME?  0
APC,LATC,APAB,LATAB  =?  20.7,36.,20.7,30.5
APC =  20.7  LC =  36.0  APAB =  20.7  LAB =  30.5
-0.14635099E+04
V = A*(D1C-D1CO) - B*(1.)

A =  0.26056196E+04   B =  0.51137753E+02
PRINT EVERY  ?TH PT?10


       POINT      MEASURED      CALC        ERR
        1          582.4        508.9       -73.4
        11        1135.3       1183.7        48.4
        21        1485.6       1382.4      -103.2
        31        1379.9       1337.4       -42.5
        41        1056.0        977.5       -78.5
        51         542.7        745.1       202.4
        61          44.8         44.1        -0.7
        71        -230.5       -270.8       -40.3
        81         174.8        194.0        19.2
        91         853.4        977.5       124.2
       101        1395.3       1333.7       -61.6
       111        1485.6       1476.1        -9.5
       121        1135.3       1090.0       -45.3
       131         635.2        752.6       117.4
       141         148.4        216.5        68.2
       151        -179.9       -263.3       -83.4
       161         -23.5        -75.9       -52.4

ERROR SQ   0.9401E+06    ERRSQ/N   0.5530E+04   RMS    0.7436E+02
CORRELATION COEFFICIENT    0.9921
ANY MORE ?NO
TT2  --  STOP
>
```

```
RUN M5
INPUT DATA FILE NAME  DK:PSRB.DAT;1
 APC,LATC,APAB,LATAB  =?  20.7,36.,20.7,30.5
APC =  20.7  LC =  36.0  APAB =  20.7  LAB =   30.5
 FRC VOL = ?  0
 FRC VOLUME IN L =      0.000
   0.61679439E+08 0.12292175E+06 0.10238236E+06 0.71447678E+08
   0.12292175E+06 0.24504753E+03 0.20410135E+03 0.14035843E+06
   0.10238236E+06 0.20410135E+03 0.17000000E+03 0.11683972E+06
   0.13622161E+05 0.75260568E+06 0.74276812E+08 0.35471727E+09
V = HO*AC - VA*AC/AA - VC
 HO  0.55248625E+02  VA   0.54526452E+04  VC   0.26039720E+05
 PRINT EVERY  ?TH PT?10


    POINT      MEASURED      CALC        ERR
      1         582.4        533.7       -48.7
     11        1135.3       1154.7        19.3
     21        1485.6       1471.8       -13.8
     31        1379.9       1412.8        32.9
     41        1056.0       1030.1       -25.9
     51         542.7        573.9        31.1
     61          44.8         60.3        15.5
     71        -230.5       -202.3        28.3
     81         174.8        169.5        -5.3
     91         853.4        885.9        32.5
    101        1395.3       1382.2       -13.1
    111        1485.6       1527.5        41.9
    121        1135.3       1138.5         3.1
    131         635.2        622.9       -12.3
    141         148.4        130.8       -17.5
    151        -179.9       -174.8         5.1
    161         -23.5        -63.1       -39.6

 ERROR SQ   0.1035E+06   ERRSQ/N   0.6086E+03   RMS   0.2467E+02
 CORRELATION COEFFICIENT   0.9991
 ANY MORE ?NO
TT2  --  STOP
>
```

```
RUN M6
 INPUT DATA FILE NAME  DK:PSRB.DAT#1
 APC,LATC,APAB,LATAB  =?  20.7,36.,20.7,30.5
APC =  20.7  LC =  36.0  APAB =  20.7  LAB =  30.5
 FRC VOL = ?  0
 FRC VOLUME IN L =    0.000
   0.68712757E+05 0.60359670E+02 0.28849821E+04 0.30638805E+07
   0.60359670E+02 0.74073050E-01 0.34456037E+01 0.24492416E+04
   0.28849821E+04 0.34456037E+01 0.17000000E+03 0.11683972E+06
   0.13622166E+05 0.75260603E+06 0.74276729E+08 0.19042154E+07
 -0.38364E-01  -0.28492E-04  -0.13270E-02
V = HO*(AC-ACO) - VA*(AC/AA - ACO/AAO) - VC
 HO  0.55248631E+02  VA   0.54526372E+04  VC   0.13978799E+03
 PRINT EVERY  ?TH PT?10


        POINT       MEASURED      CALC         ERR
          1          582.4        533.7       -48.7
         11         1135.3       1154.7        19.3
         21         1485.6       1471.8       -13.8
         31         1379.9       1412.8        32.9
         41         1056.0       1030.1       -25.9
         51          542.7        573.9        31.1
         61           44.8         60.3        15.5
         71         -230.5       -202.3        28.3
         81          174.8        169.5        -5.3
         91          853.4        885.9        32.5
        101         1395.3       1382.2       -13.1
        111         1485.6       1527.5        41.9
        121         1135.3       1138.5         3.1
        131          635.2        622.9       -12.3
        141          148.4        130.8       -17.5
        151         -179.9       -174.8         5.1
        161          -23.5        -63.1       -39.6


 ERROR SQ   0.1035E+06   ERRSQ/N   0.6086E+03  RMS   0.2467E+02
 NEW OFFSET  AND VC   0.000 139.788
 CORRELATION COEFFICIENT   0.9991
 REPRINT DATA WITH NEW VC?   N
 ANY MORE ?N
TT2  --  STOP
>
```

```
RUN M7
 INPUT DATA FILE NAME   DK:PSRB.DAT;1
 APC,LATC,APAB,LATAB  =?  20.7,36.,20.7,30.5
APC =  20.7  LC =  36.0  APAB =  20.7  LAB =  30.5
 FRC VOL = ?  0
 FRC VOLUME IN L =     0.000
  0.61679439E+08 0.51373341E+08 0.10238236E+06 0.71447619E+08
  0.51373341E+08 0.42790040E+08 0.85276428E+05 0.59477517E+08
  0.10238236E+06 0.85276428E+05 0.17000000E+03 0.11683972E+06
  0.23749693E+10 0.10533872E+12-0.31028363E+11 0.77372490E+14
V = HO*AC - VA*AA - VC
 HO  0.44353719E+02  VA  -0.13064743E+02  VC   0.32578312E+05
 PRINT EVERY  ?TH PT?10


    POINT      MEASURED       CALC          ERR
      1         582.4         533.7        -48.7
     11        1135.3        1154.7         19.4
     21        1485.6        1472.3        -13.3
     31        1379.9        1412.5         32.6
     41        1056.0        1029.8        -26.2
     51         542.7         574.2         31.5
     61          44.8          60.1         15.2
     71        -230.5        -201.9         28.6
     81         174.8         169.6         -5.2
     91         853.4         885.7         32.4
    101        1395.3        1381.9        -13.4
    111        1485.6        1527.7         42.0
    121        1135.3        1138.1          2.8
    131         635.2         623.3        -12.0
    141         148.4         130.8        -17.5
    151        -179.9        -175.1          4.8
    161         -23.5         -63.2        -39.7


 ERROR SQ   0.1034E+06   ERRSQ/N   0.6080E+03  RMS   0.2466E+02
 CORRELATION COEFFICIENT    0.9991
 ANY MORE ?NO
TT2  --  STOP
>
```

```
*************************************************************************


PREPARING PLOTS FOR THE CURVE FITS


*************************************************************************


RUN CALC
 DO YOU NEED MODEL DESCRIPTION?   YES



          MODEL CALCULATIONS FOR ELIPTIC CYLINDERS



   TYPE 1    V = A*(AC-ACO) - B*(AAB-AABO)
   TYPE 2    V = A*(D1C(DIAM)-D1CO) - B*(D1A(DIAM) - D1AO)
   TYPE 3    V = A - B*(APAB(DIAM)- APABO)
   TYPE 4    V = A*(APC(DIAM)-APCO) - B
   TYPE 5    V = A*(AC) - B*(AC/AAB) - C
   TYPE 6    V = A*(AC-ACO) - B*(*AC/AAB-ACO/AABO) - C
   TYPE 7   V = A*AC - B*AAB - C



  INPUT DATA FILE NAME   DK:PSRB.DAT;1
  MODEL TYPE?   1


  COMPARISON FOR MODEL TYPE   1


  PLOT COMPARISON ?   YES
  FILE NAME?   M1.PLO;1
  APC,LATC,APAB,LATAB  =?   20.7,36.,20.7,30.5
 APC =   20.7   LC =   36.0   APAB =   20.7   LAB =   30.5
  FRC VOL = ?   0
  FRC VOLUME IN L =      0.000
  A,B,C =?   31.541519,-27.743046
  A   0.31541519E+02   B   -0.27743046E+02   C    0.00000000E+00
  PRINT EVERY   ?TH PT?169


    POINT        MEASURED       CALC          ERR
     1            582.4         559.3         -23.1
    170           639.7         697.9          58.2

  ERROR SQ    0.2928E+06    ERRSQ/N   0.1722E+04   RMS   0.4150E+02
  OFFSET ?   NO
  CORRELATION COEFFICIENT      0.9978    -16 -
  REPRINT DATA WITH NEW C?   NO
  EVERY ?TH POINT PLOTTED?   2
```

```
ANY MORE ON THIS FILE?   YES
MODEL TYPE?   2


COMPARISON FOR MODEL TYPE   2


PLOT COMPARISON ?   YES
FILE NAME?   M2.PLO;1
NEW CHEST DIMENSIONS ?NO
FRC VOL = ?   0
FRC VOLUME IN L =     0.000
A,B,C =?   2486.6968,-141.99380
A   0.24866968E+04   B   -0.14199380E+03   C    0.00000000E+00
PRINT EVERY   ?TH PT?169


    POINT       MEASURED       CALC         ERR
     1           582.4         489.3        -93.1
    170          639.7         677.3         37.6

ERROR SQ   0.7859E+06   ERRSQ/N   0.4623E+04   RMS   0.6799E+02
OFFSET ?   NO
CORRELATION COEFFICIENT   0.9935
REPRINT DATA WITH NEW C?   NO
EVERY ?TH POINT PLOTTED?   2
ANY MORE ON THIS FILE?   YES
MODEL TYPE?   3


COMPARISON FOR MODEL TYPE   3


PLOT COMPARISON ?   YES
FILE NAME?   M3.PLO;1
NEW CHEST DIMENSIONS ?NO
FRC VOL = ?   N\N\0
FRC VOLUME IN L =     0.000
A,B,C =?   1070.5438,-2233.0249
A   0.10705438E+04   B   -0.22330249E+04   C    0.00000000E+00
PRINT EVERY   ?TH PT?169


    POINT       MEASURED       CALC        ERR
     1           582.4         359.7       -222.7
    170          639.7         671.1        31.5

ERROR SQ   0.2181E+07   ERRSQ/N   0.1283E+05   RMS   0.1133E+03
OFFSET ?   NO
CORRELATION COEFFICIENT   0.9815
REPRINT DATA WITH NEW C?   NO
EVERY ?TH POINT PLOTTED?   2
ANY MORE ON THIS FILE?   YES
MODEL TYPE?   4


COMPARISON FOR MODEL TYPE   4


PLOT COMPARISON ?   Y
FILE NAME?   M4.PLO;1
NEW CHEST DIMENSIONS ?N
FRC VOL = ?   0                              -17-
FRC VOLUME IN L =     0.000
A,B,C =?   2605.619651.137753
TT2 -- EXITING DUE TO ERROR 64
```

RUN CALC
DO YOU NEED MODEL DESCRIPTION?   NO
INPUT DATA FILE NAME   DK:PSRB.DAT;1
MODEL TYPE?   4

COMPARISON FOR MODEL TYPE   4

PLOT COMPARISON ?   YES
FILE NAME?   M4.PLO;1
APC,LATC,APAB,LATAB =?   20.7,36.,20.7,30.5
APC =   20.7   LC =   36.0   APAB =   20.7   LAB =   30.5
FRC VOL = ?   0
FRC VOLUME IN L =   0.000
A,B,C =?   2605.6196,51.137753
A 0.26056196E+04   B   0.51137753E+02   C   0.00000000E+00
PRINT EVERY   ?TH PT?169


```
  .POINT      MEASURED      CALC          ERR
    1          582.4        508.9        -73.4
   170         639.7        685.1         45.5
```

ERROR SQ   0.9401E+06   ERRSQ/N   0.5530E+04   RMS   0.7456E+02
OFFSET ?   NO
CORRELATION COEFFICIENT   0.9921
REPRINT DATA WITH NEW C?   NO
EVERY ?TH POINT PLOTTED?   2
ANY MORE ON THIS FILE?   YES
MODEL TYPE?   5

COMPARISON FOR MODEL TYPE   5

PLOT COMPARISON ?   Y
FILE NAME?   M5.PLO;1
NEW CHEST DIMENSIONS ?NO
FRC VOL = ?   0
FRC VOLUME IN L =   0.000
A,B,C =?   55.248625,5452.6452,26039.72
A 0.55248625E+02   B   0.54526452E+04   C   0.26039720E+05
PRINT EVERY   ?TH PT?169


```
  POINT       MEASURED      CALC          ERR
    1          582.4        533.7        -48.7
   170         639.7        634.3         -5.4
```

ERROR SQ   0.1035E+06   ERRSQ/N   0.6086E+03   RMS   0.2467E+02
OFFSET ?   NO
CORRELATION COEFFICIENT   0.9991
REPRINT DATA WITH NEW C?   NO
EVERY ?TH POINT PLOTTED?   2
ANY MORE ON THIS FILE?   Y
MODEL TYPE?   6

COMPARISON FOR MODEL TYPE   6

PLOT COMPARISON ?   Y

```
FILE NAME?  M6.PLO#1
NEW CHEST DIMENSIONS ?N
FRC VOL = ?  O
FRC VOLUME IN L =     0.000
A,B,C =?  55.248631,5452.6372,139.78799
A  0.55248631E+02  B   0.54526372E+04  C    0.13978799E+03
PRINT EVERY   ?TH PT?169


   POINT       MEASURED       CALC          ERR
    1           582.4         533.7         -48.7
   170          639.7         634.3          -5.4

ERROR SQ   0.1035E+06   ERRSQ/N   0.6086E+03  RMS   0.2467E+02
OFFSET ?  NO
CORRELATION COEFFICIENT   0.9991
REPRINT DATA WITH NEW C?   NO
EVERY ?TH POINT PLOTTED?   2
ANY MORE ON THIS FILE?  YES
MODEL TYPE?   7


COMPARISON FOR MODEL TYPE   7


PLOT COMPARISON ?   YES
FILE NAME?   M7.PLO#1
NEW CHEST DIMENSIONS ?NO
FRC VOL = ?   O
FRC VOLUME IN L =     0.000
A,B,C =?   44.353719,-13.064743,32578.312
A  0.44353719E+02  B  -0.13064743E+02  C    0.32578312E+05
PRINT EVERY   ?TH PT?169


   POINT       MEASURED       CALC          ERR
    1           582.4         533.7         -48.7
   170          639.7         634.6          -5.1

ERROR SQ   0.1034E+06   ERRSQ/N   0.6080E+03  RMS   0.2466E+02
OFFSET ?  NO
CORRELATION COEFFICIENT   0.9991
REPRINT DATA WITH NEW C?   NO
EVERY ?TH POINT PLOTTED?   2
ANY MORE ON THIS FILE?  NO
ANY MORE ?NO
TT2  --  STOP
>
```

```
*****************************************************************


PLOTTING THE CURVE FITS


*****************************************************************


@[1,100]PLOT
>RUN [110,110]PLOT.TSK

        PROGRAM PLOT     10:01:41        08-AUG-79
DATA FILE? [DEV.NAME.EXT;VER]   M1.PLO;1
NUMBER OF GRAPHS ON THIS SHEET? (MAX 10) 2
X MINIMUM AND X MAXIMUM?
Y MINIMUM AND Y MAXIMUM?
X AXIS LABEL? <80 CHAR>
SAMPLE(TIME
Y AXIS LABEL? <80 CHAR>
VOLUME
NO. OF DECIMAL DIGITS FOR LABELING AXES? 0
ANY NOTES? <YES OR NO> YES
NOTE? <80 CHAR> M1.PLO;1
POSITION? (X,Y) .5,8.
ANY MORE? NO
--------___CALCULATING VECTORS___-------
WANT GRID PATTERN ON THE GRAPH? <YES OR NO> NO
10:02:42       08-AUG-79
ANY MORE PLOTS? YES
DATA FILE? [DEV.NAME.EXT;VER]   M2.PLO;1
NUMBER OF GRAPHS ON THIS SHEET? (MAX 10) 2
X MINIMUM AND X MAXIMUM?
Y MINIMUM AND Y MAXIMUM?
X AXIS LABEL? <80 CHAR>
SAMPLE(TIME)
Y AXIS LABEL? <80 CHAR>
VPO\OP\OLUME
NO. OF DECIMAL DIGITS FOR LABELING AXES? 0
ANY NOTES? <YES OR NO> YES
NOTE? <80 CHAR> M2.PLO;1
POSITION? (X,Y) .5,8.
ANY MORE? NO
--------___CALCULATING VECTORS___-------
WANT GRID PATTERN ON THE GRAPH? <YES OR NO> NO
10:03:40       08-AUG-79
ANY MORE PLOTS? YES
DATA FILE? [DEV.NAME.EXT;VER]   M3.PLO;1
NUMBER OF GRAPHS ON THIS SHEET? (MAX 10) 2
X MINIMUM AND X MAXIMUM?
Y MINIMUM AND Y MAXIMUM?
X AXIS LABEL? <80 CHAR>
SAMPLE(TIME)
Y AXIS LABEL? <80 CHAR>
VOLUME
NO. OF DECIMAL DIGITS FOR LABELING AXES? 0
ANY NOTES? <YES OR NO> YES                -20-
NOTE? <80 CHAR> M3.PLO;1
```

```
POSITION? (X,Y) .5,8.
ANY MORE? NO
--------___CALCULATING VECTORS___--------
WANT GRID PATTERN ON THE GRAPH? <YES OR NO> NO
10:04:30      08-AUG-79
ANY MORE PLOTS? YES
DATA FILE? [DEV.NAME.EXT;VER]   M4.PLO;1
NUMBER OF GRAPHS ON THIS SHEET? (MAX 10) 2
X MINIMUM AND X MAXIMUM?
Y MINIMUM AND Y MAXIMUM?
X AXIS LABEL? <80 CHAR>
SAMPLE(TIME)
Y AXIS LABEL? <80 CHAR>
VOLUME
NO. OF DECIMAL DIGITS FOR LABELING AXES? 0
ANY NOTES? <YES OR NO> YES
NOTE? <80 CHAR> M4.PLO;1
POSITION? (X,Y) .5,8.
ANY MORE? NO
--------___CALCULATING VECTORS___--------
WANT GRID PATTERN ON THE GRAPH? <YES OR NO> NO
10:05:24      08-AUG-79
ANY MORE PLOTS? YES
DATA FILE? [DEV.NAME.EXT;VER]   M5.PLO;1
NUMBER OF GRAPHS ON THIS SHEET? (MAX 10) 2
X MINIMUM AND X MAXIMUM?
Y MINIMUM AND Y MAXIMUM?
X AXIS LABEL? <80 CHAR>
TI\IT\SAMPLE(TIME)
Y AXIS LABEL? <80 CHAR>
VOLUME
NO. OF DECIMAL DIGITS FOR LABELING AXES? 0
ANY NOTES? <YES OR NO> YES
NOTE? <80 CHAR> M5.PLO;1
POSITION? (X,Y) .5,8.
ANY MORE? NO
--------___CALCULATING VECTORS___--------
WANT GRID PATTERN ON THE GRAPH? <YES OR NO> NO
10:06:20      08-AUG-79
ANY MORE PLOTS? YES
DATA FILE? [DEV.NAME.EXT;VER]   M6.PLO;1
NUMBER OF GRAPHS ON THIS SHEET? (MAX 10) 2
X MINIMUM AND X MAXIMUM?
Y MINIMUM AND Y MAXIMUM?
X AXIS LABEL? <80 CHAR>
SAMPLE(TIME)
Y AXIS LABEL? <80 CHAR>
VOLUME
NO. OF DECIMAL DIGITS FOR LABELING AXES? 0
ANY NOTES? <YES OR NO> YES
NOTE? <80 CHAR> M6.PLO;1
POSITION? (X,Y) .5,8.
ANY MORE? NO
--------___CALCULATING VECTORS___--------
WANT GRID PATTERN ON THE GRAPH? <YES OR NO> NO
10:07:10      08-AUG-79
ANY MORE PLOTS? YES
DATA FILE? [DEV.NAME.EXT;VER]   M7.PLO;1
NUMBER OF GRAPHS ON THIS SHEET? (MAX 10) 2
X MINIMUM AND X MAXIMUM?
Y MINIMUM AND Y MAXIMUM?
X AXIS LABEL? <80 CHAR>
SAMPLE(TIME)                          -21-
Y AXIS LABEL? <80 CHAR>
VOLUME
NO. OF DECIMAL DIGITS FOR LABELING AXES? 0
```

```
ANY NOTES? <YES OR NO> YES
NOTE? <80 CHAR> M7.PLO;1
POSITION? (X,Y) .5,8.
ANY MORE? NO
-------___CALCULATING VECTORS___-------
WANT GRID PATTERN ON THE GRAPH? <YES OR NO> NO
10:07:58      08-AUG-79
ANY MORE PLOTS? NO
TT2   --   STOP   END OF PROGRAM PLOT
>* WHAT IS YOUR TERMINAL NUMBER 'TTN' [S]: TT2
>NFT @PLTT2
>PIP PLTT2.CMD;*,PLTT2A.CMD;*,PLTT2B.CMD;*/DE
>@ <EOF>
>
```

Appendix 2: Program ALLDAT

```
      C*****************************************************************
      C
      C
      C                        ALLDAT
      C
      C
      C*****************************************************************
      C     THIS PROGRAM PRINTS THE RAW DATA THAT HAS BEEN SAMPLED WITH
      C     DATLOG.  IT MAY BE USED TO GET A FEELING FOR
      C     THE DATA BUT PRINTING EVERY PIECE OF DATA WASTES MUCH TIME.
      C     YOU MAY ASK FOR ONLY REPRESENTATIVE POINTS TO BE PRINTED
      C*****************************************************************
0001          DIMENSION A(6),B(200),FILE(10)
0002   30     FORMAT(5(3X,F9.4))
0003   700    TYPE 29
0004   29     FORMAT('  FILE NAME?  ',$)
0005   28     FORMAT(6A4)
0006          ACCEPT 55,FILE
0007   55     FORMAT(10A4)
0008          CALL ASSIGN(3,FILE,0)
0009          CALL FDBSET(3,'READONLY')
0010          READ(3,ERR=700)DUM
0011          REWIND 3
0012          TYPE 705
0013   705    FORMAT('  PRINT EVERY ?TH POINT?  ',$)
0014          ACCEPT 706,N
0015   706    FORMAT(I3)
0016          TYPE 707,N
0017   707    FORMAT('  EVERY ',I3,'TH POINT IS PRINTED'///)
0018          IC = N-1
0019   1      CONTINUE
0020          READ (3,END=50) (A(I),I=1,6)
0021          IC = IC + 1
0022          IF(IC/N*N.NE.IC)GO TO 1
0024          TYPE 30,(A(K),K=1,5)
0025          GO TO 1
0026   98     CONTINUE
0027   31     FORMAT(2X,I3)
0028   50     STOP
0029          END
```

z

Appendix 3: Program PLT

```
      C*********************************************************************
      C
      C
      C                         PLT
      C
      C
      C*********************************************************************
      C     THIS IS THE MAIN DATA REDUCTION PROGRAM FOR DATA FROM
      C     DATLOG.  THE PROGRAM WILL TELL YOU MINIMUM AND
      C     MAXIMUM VALUES FOR EACH CHANNEL,AND PREPARE THE DATA FOR
      C     @[1,100] PLOT. YOU MAY ALSO 'DC OFFSET' THE DATA
      C     BY THE AVERAGE OF THE FIRST 'N1' AND LAST 'N2'
      C     DATA POINTS.  IF YOU WANT THE BEGINING DO BE ZERO USE N1>0
      C     AND N2=0.  IF YOU WANT THE LAST TO BE ZERO USE N1=0 AND N2>0
      C     YOU MAY OF COURSE USE N1 = N2 = 0 AND YOU WILL GET NO
      C     OFFSET.  THE DATA AFTER BEING OFFSET WILL BE WRITTEN TO A
      C     NEW FILE IF YOU CHOOSE.  REMEMBER YOU MAY ONLY PLOT 100
      C     DATA POINTS IN@[1,100]PLOT.
      C*********************************************************************
0001          DIMENSION SUM(50),JMIN(5),JMAX(5)
0002          DIMENSION X(6),XMIN(5),XMAX(5),Y(5,1250)
0003          DIMENSION FILE(10)
0004          DATA YB/1HY/
0005          GO TO 700
0006   751    CONTINUE
0007          TYPE 755
0008   755    FORMAT('   ANY MORE  ?   ',$)
0009          ACCEPT 721,RRR
0010          IF(RRR.NE.YB)GO TO 752
0012   700    TYPE 701
0013   701    FORMAT('  INPUT FILENAME   ',$)
0014          ACCEPT 702,FILE
0015   702    FORMAT(10A4)
0016          CALL ASSIGN(3,FILE,0)
0017          CALL FDBSET(3,'READONLY')
0018          READ(3,ERR=700)DUM
0019          REWIND 3
0020          TYPE 720
0021   720    FORMAT('  WRITE MODIFIED DATA TO FILE?',$)
0022          ACCEPT 721,R
0023   721    FORMAT(A1)
0024          IF(R.NE.YB) GO TO 725
0026   710     TYPE 711
0027   711    FORMAT('  OUTPUT FILE NAME   ',$)
0028   712    ACCEPT 702,FILE
0029          CALL ASSIGN(4,FILE,0)
0030          CALL FDBSET(4,'NEW')
0031   725    IC = 0
0032   1      READ(3,END=50) (X(I),I=1,6)
0033          IC = IC + 1
0034          DO 2 J = 1,5
0035   2      Y(J,IC) = X(J)
0036          GO TO 1
0037   50     TYPE 51,IC
```

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```
0038  51     FORMAT('  PTS ',I4,'  NO OF DATA POINTS FOR DC AVE ',$)
0039         ACCEPT 52, N1,N2
0040  52     FORMAT(I3,I3)
0041         TYPE 296,N1,N2
0042  296    FORMAT(3X,2I3)
0043         DO 4 J = 1,5
0044         SUM(J) = 0
0045         IF(N1.LE.0) GO TO 6
0047         DO 5 K = 1,N1
0048         SUM(J) = SUM(J) +Y(J,K)
0049  5      CONTINUE
0050  6      IF(N2.LE.0) GO TO 8
0052         DO 7 K = 1,N2
0053         SUM(J) = SUM(J) + Y(J,IC-K+1)
0054  7      CONTINUE
0055  8      CONTINUE
0056         IF(N1+N2.NE.0)SUM(J) = SUM(J)/(N1+N2)
0058         DO 10 K = 1,IC
0059  10     Y(J,K) = Y(J,K) - SUM(J)
0060  4      CONTINUE
0061         TYPE 58,(SUM(J),J=1,5)
0062  58     FORMAT('  OFFSETS ',5(2X,F8.3))
0063         IF(R.NE.YB)GO TO 731
0065         NSTA = 1
0066         NSTO = IC
0067         TYPE 1300
0068  1300   FORMAT('  TRUNCATE DATA? ',$)
0069         ACCEPT 721,R4
0070         IF(R4.EQ.YB) TYPE 1310
0072         IF(R4.EQ.YB) ACCEPT 1305,NSTA,NSTO
0074  1310   FORMAT('  1ST AND LAST POINTS ?  ',$)
0075  1305   FORMAT(2I4)
0076         DO 730 K= NSTA,NSTO
0077         WRITE(4)(Y(J,K),J=1,5),DUM
0078  730    CONTINUE
0079  731    CONTINUE
0080         TYPE 740
0081  740    FORMAT('  PREPARE DATA FOR PLOT?  ',$)
0082         ACCEPT 721,RR
0083         IF(RR.NE.YB)GO TO 750
0085         TYPE 760
0086  760    FORMAT('  FILE NAME FOR PLOT DATA?  ',$)
0087         ACCEPT  702,FILE
0088         CALL ASSIGN(1,FILE,0)
0089         CALL FDBSET(1,'NEW')
0090         TYPE 60
0091  60     FORMAT('  PLOT EVERY ?TH DATA POINT   ',$)
0092  77     FORMAT(2X,F8.0,',',F9.4)
0093  72     FORMAT(I3,',',I1,',')
0094         ACCEPT 61,N3
0095  61     FORMAT(I2)
0096         NC= IC/N3
0097         IF(NC*N3.NE.IC) NC=NC + 1
0099         DO 70 I = 1,5
```

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```
0100          WRITE(1,72) NC,I
0101          DO 75 K = 1,IC,N3
0102          A=K
0103          WRITE(1,77) A,Y(I,K)
0104   75     CONTINUE
0105   70     CONTINUE
0106   750    CONTINUE
0107          DO 90 J=1,5
0108          XMIN(J) = Y(J,1)
0109          XMAX(J)=Y(J,1)
0110          JMIN(J) = 1
0111          JMAX(J) = 1
0112          DO 90 K = 1,IC
0113          IF(XMIN(J).GT.Y(J,K)) JMIN(J) = K
0115          IF(XMIN(J).GT.Y(J,K))XMIN(J)= Y(J,K)
0117          IF(XMAX(J).LT.Y(J,K))JMAX(J) = K
0119          IF(XMAX(J).LT.Y(J,K))XMAX(J)=Y(J,K)
0121   90     CONTINUE
0122          TYPE 800
0123   800    FORMAT(4X,'   CHANNEL    J       MIN       J       MAX
              1DIFFERENCE    ')
0124          DO 89 K = 1,5
0125   89     TYPE 95,K,JMIN(K),XMIN(K),JMAX(K),XMAX(K),XMAX(K)-XMIN(K)
0126          CALL CLOSE(3)
0127          IF(RR.EQ.YB)CALL CLOSE(1)
0129   95     FORMAT(7X,I3,4X,I4,3X,F8.3,3X,I4,3X,F8.3,5X,F8.3)
0130          IF(R.EQ.YB)CALL CLOSE(4)
0132          GO TO 751
0133   752    STOP
0134          END
```

Appendix 4: Program COMPARE

```
      C****************************************************************
      C
      C
      C         COMPARE
      C
      C
      C****************************************************************
      C
      C    THIS PROGRAM COMPARES THE OUTPUT OF ANY TWO CHANNELS OF
      C    DATA IN A FORMAT CONSISTENT WITH THE OUTPUT OF DATLOG
      C
      C
      C****************************************************************
0001          DIMENSION B(6)
0002          DIMENSION X(6,999)
0003          DIMENSION FILE(10)
0004          DATA Y/1HY/
0005   100    FORMAT(10A4)
0006   110    FORMAT(I3,',',I1,',',)
0007   120    FORMAT(2X,F8.4,',',F8.4)
0008   135    CONTINUE
0009          NN = 0
0010   1      TYPE 101
0011   101    FORMAT(//'  INPUT FILE?  ',$)
0012          ACCEPT 100,FILE
0013          CALL ASSIGN(3,FILE,0)
0014          CALL FDBSET(3,'READONLY')
0015          READ(3,ERR=1)DUM
0016          REWIND 3
0017          TYPE 102
0018   102    FORMAT('  OUTPUT FILE?  ',$)
0019          ACCEPT 100,FILE
0020          CALL ASSIGN(4,FILE,0)
0021          CALL FDBSET(4,'NEW')
0022          TYPE 103
0023   103    FORMAT(' CHANNEL  ? = X?  ',$)
0024          ACCEPT 104,N1
0025   104    FORMAT(I1)
0026          TYPE 105
0027   105    FORMAT(' CHANNEL ? = Y?  ',$)
0028          ACCEPT 104,N2
0029          IC = 0
0030          READ(3)(B(I),I=1,6)
0031          XMIN = B(N1)
0032          XMAX = XMIN
0033          YMIN = B(N2)
0034          YMAX = YMIN
0035          REWIND 3
0036   25     READ(3,END=50)(X(I,IC+1),I=1,6)
0037          IF(X(N1,IC+1).LT.XMIN) XMIN = X(N1,IC+1)
0039          IF(X(N1,IC+1).GT.XMAX) XMAX = X(N1,IC+1)
0041          IF(X(N2,IC+1).LT.YMIN) YMIN = X(N2,IC+1)
0043          IF(X(N2,IC+1).GT.YMAX) YMAX = X(N2,IC+1)
0045          IC = IC + 1
```

```
0046          GO TO 25
0047    50    WRITE(4,110)IC,NN
0048          TYPE 150,XMIN,XMAX
0049          TYPE 151, YMIN,YMAX
0050    150   FORMAT('   XMIN ',F8.4,'  XMAX  ',F8.4)
0051    151   FORMAT('   YMIN ',F8.4,'  YMAX  ',F8.4)
0052          DO 30I =1,IC
0053    30    WRITE(4,120)X(N1,I),X(N2,I)
0054          CALL CLOSE(3)
0055          CALL CLOSE(4)
0056          TYPE 130
0057    130   FORMAT('  ANY MORE?  ',$)
0058          ACCEPT 131,YB
0059          IF(YB.EQ.Y) GO TO 135
0061    131   FORMAT(A1)
0062          STOP
0063          END
```

```
FORTRAN IV      STORAGE MAP

NAME     OFFSET   ATTRIBUTES

B        000006   REAL*4     ARRAY (6)
X        000036   REAL*4     ARRAY (6,999) VECTORED
FILE     056706   REAL*4     ARRAY (10)
Y        056756   REAL*4     VARIABLE
NN       063222   INTEGER*2  VARIABLE
ASSIGN   000000   REAL*4     PROCEDURE
FDBSET   000000   REAL*4     PROCEDURE
DUM      063224   REAL*4     VARIABLE
N1       063230   INTEGER*2  VARIABLE
N2       063232   INTEGER*2  VARIABLE
IC       063234   INTEGER*2  VARIABLE
I        063236   INTEGER*2  VARIABLE
XMIN     063240   REAL*4     VARIABLE
XMAX     063244   REAL*4     VARIABLE
YMIN     063250   REAL*4     VARIABLE
YMAX     063254   REAL*4     VARIABLE
CLOSE    000000   REAL*4     PROCEDURE
YB       063260   REAL*4     VARIABLE

>
```

Appendix 5:   Program M5

```
      C********************************************************************
      C
      C
      C         M5 CURVE FIT FOR MODEL 5 3 PARAMETER MODEL
      C
      C
      C********************************************************************
0001        DOUBLE PRECISION DC,DA,V,APC,XLC,APAB,XLAB,VFRC
0002        DOUBLE PRECISION PI,D1C,D2C,D1A,D2A,HO,VA,VC,SER,SX
           1,SX2,SY,SY2,SXY,VM,D2D,VV,ER,CC
0003        DIMENSION FILE(10)
0004        DOUBLE PRECISION S(12),XIC,DETC,XN1,XN2,XN3
0005        DOUBLE PRECISION AO
0006        DATA YY/1HY/
0007        NDIC = 0
0008  900   TYPE 600
0009  600   FORMAT('  INPUT DATA FILE NAME  ',$)
0010        ACCEPT  601,FILE
0011  601   FORMAT(10A4)
0012        CALL ASSIGN(3,FILE,0)
0013        CALL FDBSET(3,'READONLY')
0014        READ(3,ERR=900)DUM
0015        REWIND 3
0016        IF(NDIC.EQ.0. ) GO TO 2002
0018        TYPE 432
0019        ACCEPT 401,YB
0020        IF(YB.NE.YY) GO TO 433
0022  432   FORMAT('  NEW CHEST DIMENSIONS ?',$)
0023  2002  TYPE 602
0024  602   FORMAT('  APC,LATC,APAB,LATAB  =?  ',$)
0025        ACCEPT 603,APC,XLC,APAB,XLAB
0026        TYPE 619,APC,XLC,APAB,XLAB
0027  619   FORMAT(' APC =',F6.1,'  LC =',F6.1,'  APAB =',F6.1,'  LAB ='
           1,F6.1)
0028        NDIC = 1
0029  603   FORMAT(4F8.0)
0030  433   TYPE 500
0031  500   FORMAT('  FRC VOL = ?  ',$)
0032        ACCEPT 501 ,VFRC
0033  501   FORMAT(F8.3)
0034        TYPE 502 ,VFRC
0035  502   FORMAT('  FRC VOLUME IN L = ',F8.3)
0036        IC=1
0037        DO 56 I = 1,12
0038  56    S(I) = 0
0039        AO= APC*XLC
0040        PI=3.1415926
0041  60    READ(3,END=50) (VVV,D1CC,D2CC,D1AC,D2AC,DUM)
0042        V = VVV
0043        D1C = D1CC
0044        D2C = D2CC
0045        D1A=D1AC
0046        D2A=D2AC
0047        D1C=D1C + APC
```

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```
0048            D2C= D2C +  XLC
0049            D1A = D1A + APAB
0050            D2A = D2A + XLAB
0051            DC = PI*D1C*D2C/4.
0052            DA = PI*D1A*D2A/4.
0053  678       FORMAT(2X,F8.3)
0054            V =( V  +VFRC)*1000.
0055            S(1) = S(1) + DC*DC
0056            S(2) = S(2) + DC/DA*DC
0057            S(3) = S(3) + DC
0058            S(4) = S(4)+ V*DC
0059            S(6) = S(6) + DC*DC/DA/DA
0060            S(7) = S(7) + DC/DA
0061            S(8) = S(8) + DC*V/DA
0062            S(11) = S(11) + 1
0063            S(12) = S(12) + V
0064            IC = IC + 1
0065            GO TO 60
0066  50        S(5) = S(2)
0067            S(9) = S(3)
0068            S(10) = S(7)
0069            TYPE 99,(S(I),I=1,12)
0070            DETC = S(1)*(S(6)*S(11) - S(7)*S(10))
0071            DETC = DETC + S(9)*(S(2)*S(7)-S(3)*S(6))
0072            DETC = DETC -S(5)*(S(2)*S(11)-S(3)*S(10))
0073            XN1 = S(4)*(S(6)*S(11)-S(7)*S(10))
0074            XN1 = XN1 + S(12)*(S(2)*S(7)-S(3)*S(6))
0075            XN1 = XN1 - S(8)*(S(2)*S(11)-S(3)*S(10))
0076            XN2 = S(1)*(S(7)*S(12)-S(8)*S(11))
0077            XN2 = XN2 + S(9)*(S(3)*S(8)-S(4)*S(7))
0078            XN2 = XN2 - S(5)*(S(3)*S(12)-S(4)*S(11))
0079            XN3 = S(1)*(S(8)*S(10)-S(6)*S(12))
0080            XN3 = XN3 + S(9)*(S(4)*S(6)-S(2)*S(8))
0081            XN3 = XN3 - S(5)*(S(4)*S(10)-S(2)*S(12))
0082            IC = IC -1
0083            TYPE 99,DETC,XN1,XN2,XN3
0084  99        FORMAT(2X,4E15.8)
0085            HO = XN1/DETC
0086            VA = XN2/DETC
0087            VC= XN3/DETC
0088            TYPE 71
0089  71        FORMAT(' V = HO*AC - VA*AC/AA - VC ')
0090            TYPE 70,HO,VA,VC
0091  70        FORMAT('  HO 'E15.8,'  VA ',E15.8,'  VC ',E15.8)
0092            TYPE 1000
0093  1000      FORMAT('  PRINT EVERY  ?TH PT?',$)
0094            ACCEPT 1001,NPO
0095  1001      FORMAT(I3)
0096            IC = 1
0097            SER = 0
0098            SX = 0
0099            SX2 = 0
0100            SY = 0
0101            SY2 = 0
```

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```
0102          SXY = 0
0103          REWIND 3
0104          TYPE 490
0105    490   FORMAT(//'     POINT',5X,'MEASURED',5X,'CALC',8X,'ERR')
0106    424   READ(3,END=430)(VVV,D1CC,D2CC,D1AC,D2AC,DUM)
0107          D1C = D1CC
0108          D2C = D2CC
0109          D1A = D1AC
0110          D2A = D2AC
0111          VM = VVV
0112          D1C=D1C+APC
0113          D2C=D2C+XLC
0114          D2A=D2A+XLAB
0115          D1A=D1A+APAB
0116          DC = PI*D1C*D2C/4.
0117          DA= PI*D1A*D2A/4.
0118          VV = HO*(DC) - VA*(DC/DA)-VC
0119          VM = 1000.*(VM + VFRC)
0120          ER = VV - VM
0121          SX = SX + VM
0122          SX2 = SX2 + VM*VM
0123          SY = SY + VV
0124          SY2 = SY2 + VV*VV
0125          SXY = SXY + VM*VV
0126          NN =IC + NPO-1
0127          SER = SER + ER*ER
0128          IF(NN/NPO*NPO.NE.NN)GO TO 1003
0130          TYPE 425, IC,VM,VV,ER
0131    425   FORMAT(3X,I4,5X,F8.1,5X,F8.1,5X,F8.1)
0132    1003  IC = IC + 1
0133          GO TO 424
0134    430   TYPE 427,SER,SER/(IC-1),(SER/(IC-1))**.5
0135          IC = IC - 1
0136          SXY = SXY - SX*SY/IC
0137          SXY = SXY/(IC-1)
0138          SX = SX2 - SX*SX/IC
0139          SX = SX/(IC-1)
0140          SX = SX**.5
0141          SY = SY2 - SY*SY/IC
0142          SY = SY/(IC-1)
0143          SY = SY**.5
0144          CC = SXY/SX/SY
0145          TYPE 1100,CC
0146    1100  FORMAT('  CORRELATION COEFFICIENT ',F8.4)
0147    427   FORMAT(/'  ERROR SQ ',E12.4,3X,'ERRSQ/N ',E12.4,'  RMS ',
               1E12.4)
0148    400   FORMAT('  ANY MORE ?',$)
0149          TYPE 400
0150          CALL CLOSE(3)
0151    401   FORMAT(A1)
0152          ACCEPT  401,YB
0153          IF(YB.EQ.YY)GO TO 900
0155          STOP
0156          END
```

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Appendix 6: Program CALC

```
      C*****************************************************************
      C
      C
      C           PROGRAM CALC
      C
      C      PREPARES MODEL FITS FOR VERSATEC PLOTTING
      C
      C
      C*****************************************************************
0001        DOUBLE PRECISION DC,DA,VV,HO,HO,VA,VC
0002        DOUBLE PRECISION VM,APC,XLC,APAB,XLAB,VFRC,PI,CONS,SER,SX
0003        DOUBLE PRECISION SX2,SY,SY2,SXY,DCO,DAO,D1CO,D1AO,D2CO,D2AO
0004        DOUBLE PRECISION D1C,D2C,D1A,D2A,D2D,ER,CC
0005        DIMENSION VV(999),VM(999)
0006        DIMENSION FILE(10)
0007        DOUBLE PRECISION S(12),XIC,DETC,XN1,XN2,XN3
0008        DOUBLE PRECISION AO
0009        DATA YY/1HY/
0010        TYPE 4000
0011  4000  FORMAT('  DO YOU NEED MODEL DESCRIPTION?   ',$)
0012        ACCEPT 401,Y
0013        IF(Y.NE.YY) GO TO 4005
0015        TYPE 4010
0016  4010  FORMAT(/////'           MODEL CALCULATIONS FOR ELIPTIC CYLINDERS'
           1////)
0017        TYPE 4006
0018  4006  FORMAT('   TYPE 1   V = A*(AC-ACO) - B*(AAB-AABO) '/
           1'   TYPE 2   V = A*(D1C(DIAM)-D1CO) - B*(D1A(DIAM) - D1AO)'/
           2'   TYPE 3   V = A - B*(APAB(DIAM)- APABO)'/
           3' · TYPE 4   V = A*(APC(DIAM)-APCO) - B'/
           4'   TYPE 5   V = A*(AC) - B*(AC/AAB) - C'/
           5'   TYPE 6   V = A*(AC-ACO) - B*(*AC/AAB-ACO/AABO) - C'/
           6'   TYPE 7   V = A*AC - B*AAB - C'////)
0019  4005  CONTINUE
0020        NDIC = 0
0021  900   TYPE 600
0022  600   FORMAT('   INPUT DATA FILE NAME   ',$)
0023        ACCEPT  601,FILE
0024  601   FORMAT(10A4)
0025        CALL ASSIGN(3,FILE,0)
0026        CALL FDBSET(3,'READONLY')
0027        READ(3,ERR=900)DUM
0028  4999  REWIND 3
0029        TYPE 6000
0030  6000  FORMAT('  MODEL TYPE?  ',$)
0031        ACCEPT 1001,MTY
0032        TYPE 6001, MTY
0033  6001  FORMAT(//'  COMPARISON FOR MODEL TYPE',I3//)
0034        TYPE 9876
0035  9876  FORMAT('  PLOT COMPARISON ?   ',$)
0036        ACCEPT 401,YYYY
0037        IF(YYYY.NE.YY)GO TO 9875
0039        TYPE 9874
0040  9874  FORMAT('  FILE NAME?  ',$)
```

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```
0041          ACCEPT 601,FILE
0042          CALL ASSIGN(4,FILE,0)
0043          CALL FDBSET(4,'NEW')
0044    9875  CONTINUE
0045          IF(NDIC.EQ.0. ) GO TO 2002
0047          TYPE 432
0048          ACCEPT 401,YB
0049          IF(YB.NE.YY) GO TO 433
0051    432   FORMAT('  NEW CHEST DIMENSIONS ?',$)
0052    2002  TYPE 602
0053    602   FORMAT('  APC,LATC,APAB,LATAB  =?  ',$)
0054          ACCEPT 603,APC,XLC,APAB,XLAB
0055          TYPE 619,APC,XLC,APAB,XLAB
0056    619   FORMAT(' APC =',F6.1,'  LC =',F6.1,'   APAB =',F6.1,'  LAB ='
             1,F6.1)
0057          NDIC = 1
0058    603   FORMAT(4F8.0)
0059    433   TYPE 500
0060    500   FORMAT('  FRC VOL = ?  ',$)
0061          ACCEPT 501 ,VFRC
0062    501   FORMAT(F8.3)
0063          TYPE 502 ,VFRC
0064    502   FORMAT('  FRC VOLUME IN L = ',F8.3)
0065          IC=1
0066          DO 56 I = 1,12
0067    56    S(I) = 0
0068          AO= APC*XLC
0069          PI=3.1415926
0070          GO TO 1234
0071    678   FORMAT(2X,F8.3)
0072    1300  FORMAT(3(2X,E12.5))
0073    1234  CONTINUE
0074          TYPE 1235
0075    1235  FORMAT('  A,B,C =?  ',$)
0076          ACCEPT 1236,HO,VA,VC
0077    1236  FORMAT(3F12.0)
0078          CONS = 0
0079    999   TYPE 70,HO,VA,VC
0080    70    FORMAT('  A 'E15.8,'  B ',E15.8,'  C ',E15.8)
0081    76    FORMAT(F8.0)
0082          TYPE 1000
0083    1000  FORMAT('  PRINT EVERY   ?TH PT?',$)
0084          ACCEPT 1001,NPO
0085    1001  FORMAT(I3)
0086          IC = 1
0087          SER = 0
0088          SX = 0
0089          SX2 = 0
0090          SY = 0
0091          SY2 = 0
0092          SXY = 0
0093          DCO = PI*APC*XLC/4.
0094          DAO = PI*APAB*XLAB/4.
0095          D1CO = APC                -38-
```

```
0096          D1AO = APAB
0097          D2CO = XLC
0098          D2AO = XLAB
0099          REWIND 3
0100          TYPE 490
0101     490  FORMAT(//'    POINT',5X,'MEASURED',5X,'CALC',8X,'ERR')
0102     424  READ(3,END=430)(VVM,DD1,DD2,DD3,DD4,DUM)
0103          D1C= DD1
0104          D2C=DD2
0105          D1A=DD3
0106          D2A=DD4
0107          VM(IC) = VVM
0108          D1C=D1C+APC
0109          D2C=D2C+XLC
0110          D2A=D2A+XLAB
0111          D1A=D1A+APAB
0112          DC = PI*D1C*D2C/4.
0113          DA= PI*D1A*D2A/4.
0114          IF(MTY.EQ.1) VV(IC) = HO*(DC - DCO) - VA*(DA-DAO)+ CONS
0116          IF(MTY.EQ.2) VV(IC) = HO*(D1C-D1CO) - VA*(D1A-D1AO)+ CONS
0118          IF(MTY.EQ.3) VV(IC) = HO - VA*(D1A-D1AO)
0120          IF(MTY.EQ.4) VV(IC) = HO*(D1C-D1CO) - VA
0122          IF(MTY.EQ.5) VV(IC) = HO*DC - VA*DC/DA - VC
0124          IF(MTY.EQ.6) VV(IC) = HO*(DC-DCO) -VA*(DC/DA-DCO/DAO) - VC
0126          IF(MTY.EQ.7) VV(IC) = HO*DC - VA*DA - VC
0128          VM(IC) = 1000.*(VM(IC) + VFRC)
0129          ER = VV(IC) - VM(IC)
0130          SX = SX + VM(IC)
0131          SX2 = SX2 + VM(IC)*VM(IC)
0132          SY = SY + VV(IC)
0133          SY2 = SY2 + VV(IC)*VV(IC)
0134          SXY = SXY + VM(IC)*VV(IC)
0135          NN =IC + NPO-1
0136          SER = SER + ER*ER
0137          IF(NN/NPO*NPO.NE.NN)GO TO 1003
0139          TYPE 425, IC,VM(IC),VV(IC),ER
0140     425  FORMAT(3X,I4,5X,F8.1,5X,F8.1,5X,F8.1)
0141    1003  IC = IC + 1
0142          GO TO 424
0143     430  TYPE 427,SER,SER/(IC-1),(SER/(IC-1))**.5
0144          IC = IC - 1
0145          CONS = (SX-SY)/IC
0146          TYPE 9000
0147    9000  FORMAT('  OFFSET ?  ',$)
0148          ACCEPT 401,HY
0149          IF(HY.NE.YY) GO TO 9001
0151          IF(MTY.EQ.3) HO = HO + CONS
0153          IF(MTY.EQ.4) VA = VA -CONS
0155          IF(MTY.EQ.5.OR.MTY.EQ.6.OR.MTY.EQ.7) VC = VC-CONS
0157          TYPE 77,CONS
0158      77  FORMAT('  NEW OFFSET   ',F12.3,3X,F12.3)
0159    9001  SXY = SXY - SX*SY/IC
0160          SXY = SXY/(IC-1)
0161          SX = SX2 - SX*SX/IC
```

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```
0162          SX = SX/(IC-1)
0163          SX = SX**.5
0164          SY = SY2 - SY*SY/IC
0165          SY = SY/(IC-1)
0166          SY = SY**.5
0167          CC = SXY/SX/SY
0168          TYPE 1100,CC
0169          TYPE 1200
0170   1200   FORMAT('   REPRINT DATA WITH NEW C?   ',$)
0171          ACCEPT   401,YB
0172          IF(YB.EQ.YY) GO TO 999
0174   1100   FORMAT('   CORRELATION COEFFICIENT ',F8.4)
0175   427    FORMAT(//'   ERROR SQ ',E12.4,3X,'ERRSQ/N ',E12.4,'   RMS
              1E12.4)
0176   400    FORMAT('   ANY MORE ?',$)
0177          IF(YYYY.NE.YY) GO TO 8755
0179          IOO = 0
0180          TYPE 8760
0181   8760   FORMAT('   EVERY ?TH POINT PLOTTED?   ',$)
0182          ACCEPT 1001 ,NP
0183          NTOT = IC/NP+ 1
0184          IF((NTOT-1)*NP.EQ.IC)NTOT = NTOT-1
0186          WRITE(4,8765)NTOT,IOO
0187          IOO = 4
0188   8765   FORMAT(I3,',',I1,',')
0189          DO 8764 I = 1,IC,NP
0190          XIC = I
0191          WRITE(4,8763)XIC,VV(I)
0192   8764   CONTINUE
0193   8763   FORMAT(2X,F8.0,',',F9.4)
0194          WRITE(4,8765)NTOT,IOO
0195          DO 8762 I =1,IC,NP
0196          XIC = I
0197   8762   WRITE(4,8763)XIC,VM(I)
0198          CALL CLOSE(4)
0199   8755   TYPE 5000
0200   5000   FORMAT('   ANY MORE ON THIS FILE?   ',$)
0201          ACCEPT 401,Y
0202          IF(Y.EQ.YY)GO TO 4999
0204          CALL CLOSE(3)
0205          TYPE 400
0206   401    FORMAT(A1)
0207          ACCEPT   401,YB
0208          IF(YB.EQ.YY)GO TO 900
0210          STOP
0211          END
```

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